

Computer Assisted Calculus Education Project

Principal Investigator

- Name: Byungik Kahng, Assistant Professor
- Discipline: Mathematics
- E-mail: kahng@morris.umn.edu
- Phone: (320) 589-6317
- Fax: (320) 589-6371
- Address: Division of Science and Mathematics
University of Minnesota
Morris, MN 56267

Abstract

The purpose of this project is to develop the educational software for computer assisted education of calculus sequence courses. This project seeks to integrate traditional and computer based teaching rather than to develop them separately. The immediate objective of this project is to upgrade the calculus curricula in the Morris campus. Long-term objectives include the publication of the software and the development of distance learning program.

Introduction

The computer based calculus education program in University of Minnesota at Morris (UMM) was initiated originally in 1988, by Michael O'Reilly. It was finalized in 1993, partly supported by NSF DUE #9050797 from June 1990 to November 1992. The new calculus curriculum developed thus is being continued to this day in UMM, along with the traditional calculus courses. The educational software developed in this period has been a valuable asset for a number of years. After 15 years of service, however, the software is badly in need of overhaul. For instance, its graphics cannot support colors, animation, interactive real-time 3D representation, to name a few. One of the two immediate objectives of this project is to provide the much overdue upgrade.

There is also, an objective equally as important as the former, yet rather unique to the liberal art college environment. The calculus education reform movement through active learning and computer based teaching swept through many colleges and universities in the past two decades, resulting in multiple instructional strategies. Successful programs took more permanent status, and nowadays, they are being offered together with the traditional calculus courses. While this benefited many students in large universities that offer variety of options at the same time, it created a problem in small liberal art college environment. With less than a handful of sections offered each semester with no two sections at the same time slot, many students are being forced into the learning styles that do not suit them. The investigator concludes, therefore, it is necessary to integrate the traditional and the computer based teaching, thereby exposing students variety of learning styles and accommodating students' individual need and background within one section. This is a high-risk, time-consuming project that requires great deal of personal interaction with students that can be done only in high level liberal art colleges that promote such faculty-student interaction.

Project Description

The basic framework of this project will be Michael O'Reilly's *Mathematica* notebook files, developed from 1989 – 1993, which is still being used in at least one section of Calculus I or Calculus II each semester. The investigator plans to redesign the old software so that it fits the following objectives.

- ❑ Each chapter and each section of the new *Mathematica* notebooks must be self-sufficient and independent of one another, so that any part of the software can be integrated to any syllabus based on any textbook in any order.
- ❑ All the texts and programs in the new software must support traditional mathematical symbols.
- ❑ Graphics must be better contrived so that new features, such as colors, animation, interactive real time 3D representation are supported.
- ❑ The software must include a number of self-sufficient program shells, through which students can develop his/her own models in the future.
- ❑ Create new notebook files for Calculus III (Vector Calculus).

The investigator expects the first objective will be the most time-consuming and the most high-risk. However, he believes that it has also the biggest impact. It will allow a substantial part of the software to be used in *all* calculus sections, consequently affecting a large number of students. This aspect of our project is described in the second paragraph of the introduction, and also in the first paragraph of the importance of the project.

The investigator plans to employ undergraduate teaching assistants to carry out the second and the third objectives. This part will be time-consuming, but less risky and somewhat routine. To students, however, it will provide valuable learning experience, especially for those interested in career in mathematics education.

The fourth objective is important not only in educational point of view, but also in the development of this project itself. The program shells will be used to develop other parts of this software by the undergraduate teaching assistants, as well as by the investigator. The investigator expects that this part can be done in relatively short amount of time, because he has already built substantial library of shells for his classes.

The final objective will be pursued in the second year, after successful implementation of this project for Calculus I and Calculus II. The software for Calculus III needs to be built from scratch, because O'Reilly's old software does not include Calculus III.

The Importance of the Project

All science disciplines plus some social science disciplines require calculus toward their majors. Consequently, over a third of all the students in UMM take at least one of calculus sequence courses, Math 1021, Math 1101, Math 1102 and Math 2101. Therefore, the importance of the quality education of calculus cannot be emphasized too much. The investigator believes that the mathematics discipline in UMM has been doing an outstanding job providing excellence to its students, yet he also believes that it is possible to improve the current status by eliminating the two obstacles at once: the outdated software and the afore-mentioned problem unique to liberal art institution. This project will subsequently be implemented to all calculus sections, consequently affecting large number of students in UMM.

In addition, the investigator wishes to point out that the development of computer assisted calculus courses allows remote access through computer network, which will eventually pave the way for the development of distance learning program. The latter aspect is among the long-term goals of this project. It will require the successful achievement of the immediate goals and the collaboration with the colleagues in other campuses.

Project Assessment

The most important factor to assess and evaluate this project is the peer review from the colleagues in the mathematics discipline. The success of this project depends upon whether the calculus software modules developed by this project be smoothly incorporated to various sections of calculus courses taught by different instructors, based upon his/her unique teaching techniques and philosophy. The investigator plans to get frequent feedbacks and assessments from his colleagues. Some of the important issues are listed here.

- Are the modules being used in class?
- Do the modules enhance students' understanding? Do they provide them different perspectives?
- Do the modules help students model complicated and realistic problems on their own?
- Has there been any difficulty rearranging the notebook files, skipping sections, or using only small pieces of them in non-sequential order?
- Are the program shells self-sufficient and easy to manipulate? Or, is it sometimes necessary to open another notebook file in order to run a program successfully?
- Do they give away too many answers? If so, is it easy to skip sections you don't like without affecting others?
- Is too much class time being spent on technical details, such as correcting students' typos?
- Any suggestions for improvements?

The first question is about the actual use of the software in classroom environment. The second and the third questions concern its effect on students. The next four questions are directly related to some of the immediate goals of this project, namely self-sufficiency and independence. Instructors may or may not like computational and technical sections. The rest of the sections must stand by themselves when the instructors skip the computational sections in favor of more traditional methods.

Feedbacks from students and teaching assistants will also play important roles. The questions for the students' assessment will be similar to those listed above. However, the investigator does not plan to conduct extensive study on the comparative analysis on the student's performance for two equally important reasons. First, it is impossible to run controlled experiments when multiple sections are not present. It is not possible to control students' exposure to technology within one section in the same classroom, and comparing students in other sections taught by different instructors using different textbooks is pointless. Second, there has been extensive study on the pros and cons of the computer based and the computer assisted teaching, in the past 20 years. It had been concluded that it is not a question of *whether*, but *how* to incorporate technology into classrooms. The latter must be addressed through survey and suggestions rather than controlled experiment.

Timetable

Although the investigator requests funding for the first year only, the timetable for entire project is presented. An assessment will be conducted at the end of each phase.

Date	Description
May 16, 2005.	Project starts.
Aug. 26, 2005.	Target date for the completion of the beta version for both Calculus I and Calculus II.
Aug. 28 – Dec. 22, 2005.	The first implementation of Calculus I modules.
Jan. 6, 2006.	Target date for the completion of the stable version for Calculus I modules.
Jan. 9 – Jan.13, 2006.	Testing and Mentoring of the stable version for Calculus I modules.
Jan. 16 – May 12, 2006.	The first implementation of Calculus II modules. Wide use of Calculus I (expected).
May 26, 2006.	Target date for the completion of the stable version for Calculus II modules.
May 15 – Aug. 25, 2006.	The development of the software for Calculus III.
Aug. 21 – Aug. 25, 2006.	Testing and Mentoring of the stable version for Calculus II modules.
Aug. 28 – Dec. 21, 2006.	The first implementation of Calculus III. Wide use of Calculus I and II (expected).
Jan. 5, 2007.	Target date for the completion of the stable version for Calculus III modules.
Jan. 8 – Jan. 13, 2007.	Testing and Mentoring of the stable version for Calculus III modules.

The long term goals, such as, the publication and the development of distance learning program will be pursued after all modules are completed and successfully incorporated to UMM’s calculus education.

Budget

Year 1 (2005 – 2006)	TEL	UMM
Undergraduate Teaching Assistants (Summer)	\$1,230	\$1,230
Undergraduate Teaching Assistants (Fall and Spring)		\$2,280
Travel / Invitation		\$1,000
Books, Courseware and Supplies	\$120	\$240
Computer and Software	\$2,000	
Faculty Summer Salary and Benefits	\$1,400	
Year 1 Total	\$4,750	\$4,750

The proposal for the second year will be written separately.

Budget Justification

UMM is willing to support one undergraduate teaching assistant for summer 2005, and one TA for each calculus classes run by the investigator’s pilot program. The most extensive work will be put in during the summer, when our team must work full time to finish at least the beta version of the software in time. The investigator requests, therefore, additional funding to support one more student for the summer. He requests, however, only one week of salary and benefit for himself. Travel expense is necessary in order to attend conferences, to participate in and to interact with similar projects in other colleges and universities, and to invite prominent guests who oversee and review computer assisted calculus education projects in national level. The latter aspect is particularly important, because the investigator plans to apply for an NSF grant for the second and more ambitious stage of this project. He plans to do this after the first successful implementation of Calculus I pilot program in the fall 2005 semester. Here is more detailed explanation on selected items in the budget.

- Year 1 Total: \$9,500
- Summer TA(s): \$7.10 per hour for 320 hours, and 8.6% benefits during the summer 2005.
- TAs for fall and spring: \$7.10 per hour for 5 hours a week in a 16 week semester; 4TAs for 4 classes.
- Computer and Software: \$2,000 for Apple PowerBook G4 Combo and standard software.
- Faculty Summer Salary: \$2,320 per two-week period, for 1 week, and 20.2% benefits.

Sustainability

All faculty members in UMM's mathematics discipline approved and supported the investigator's plan to upgrade and redesign old notebooks. This project provides instructors with more freedom and more user friendliness to incorporate technology in their teaching than before. Therefore, the outcome of this project will continue to provide resources to calculus sequence courses for many years to come.